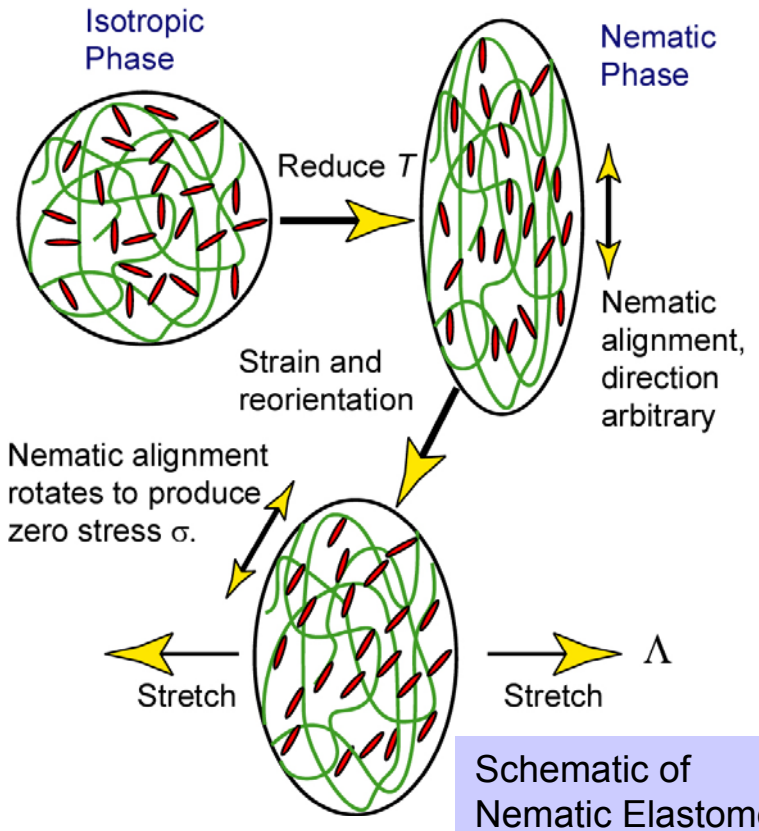
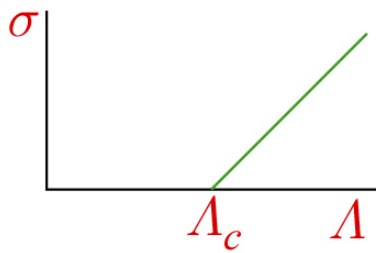
Nematic Elastomers
Tom Lubensky 02, University of Pennsylvania, Award 00-96531

Nematic Elastomers are crosslinked polymer (rubber) networks with attached or imbedded rod-like elements. Below a critical temperature, these elements align along a common direction to create an anisotropic nematic elastomer. These materials have a number of remarkable properties: their length can change by 400% upon cooling by only 10 degrees, and they exhibit "soft" elasticity whereby no stress (σ) is required to produce extensions Λ (with Λ=1 the unstretched state) up to a critical value Λ_c. These properties make nematic elastomers candidates for artificial muscles and various actuators. My collaborators and I developed* a detailed theory to describe nematic elastomers. We showed in particular that the phenomena of "soft elasticity" is a consequence of the spontaneous symmetry of the nematic state in a systems (rubber) that supports shear.

*T. C. Lubensky, Ranjan Mukhopadhyay, Leo Radzihovsky, Xiangjun Xing, "Symmetries and Elasticity of Nematic Gels", PRE, 2002



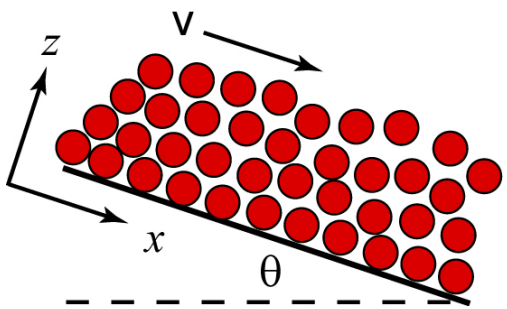
Schematic of Nematic Elastomer

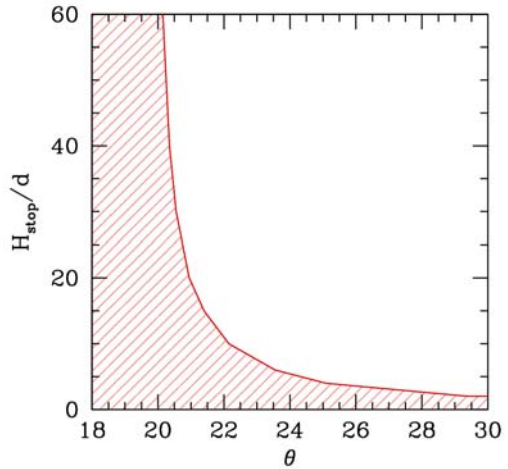


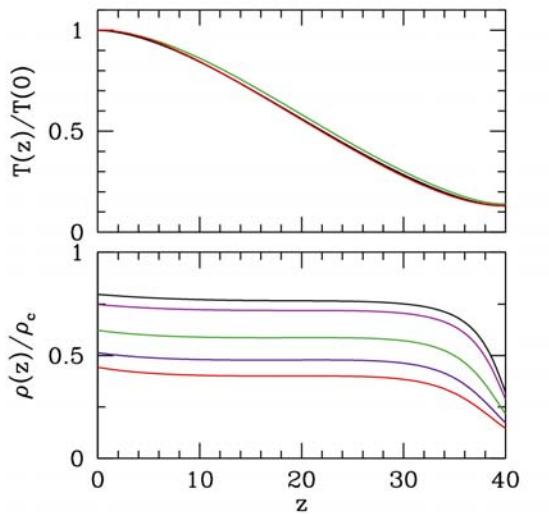
Stress – strain curve

"A Hydrodynamic model for a dynamical jammed-to-flowing transition in gravity driven granular media"
Tom Lubensky 02, University of Pennsylvania, Award 00-96531

In collaboration with Lyderic Bocquet of ENS, Lyon, I generalized our recently developed kinetic-hydrodynamic theory for granular flow to describe chute flow down and inclined plane. In this theory, flow of granular material under shear is described by continuum hydrodynamics with an energy-loss term, and transport coefficients have the temperature and density dependence of Chapman-Enskog theory. The viscosity has an anomalous divergence with density. Our chute flow theory predicts a dynamical jammed-to-flowing transition with no flow for $H<H_{stop}$ and temperature and density profiles shown at right.







Outreach
Tom Lubensky 02, University of Pennsylvania, Award 00-96531

Brief summary of outreach activities:

Educational:
0 undergraduates,
2 grad students,
2 post-docs.

My primary outreach is through my supervision of graduate students and postdocs. I have one advanced student, Arindam Kundagrami, and one new student, Fangfu Ye. Arindam is completing thesis work on the transition from the cholesteric to the TGB-C phase.
My postdocs, Olaf Stenull and Andy Lau, are working, respectivley, on anomalous elasticity in nematic elastomers and on lyotropic elastomers and depletion forces with from anisotropic particles.

I am now Chair of the Department of Physics and Astronomy at the University of Pennsylvania. As such, I am responsible for all of the educational and research activities of the Department. These include undergraduate education, graduate education, and our outreach activities such as the Penn Summer Science Academy for high school students. The latter is a very successful program that brings 30 to 40 students to Penn for four weeks for an intensive laboratory and classroom experience in physics or astronomy